TIMS-301 USER MANUAL

Telecommunications Instructional Modelling System

TIMS-301 USER MANUAL

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TIMS INTRODUCTION

TIMS OVERVIEW

TIMS is a telecommunications modelling system. It models mathematical equations representing electrical signals, or block diagrams representing telecommunications systems.

TIMS is primarily a hands-on rather than demonstration style teaching system, which combines both the theoretical and practical aspects of implementing systems. We are confident that TIMS will provide the student with a clearer understanding of the concepts behind telecommunications theory.

Physically, TIMS is a dual rack system. The top rack accepts up to 12 Eurocard sized, compatible "black boxes", or modules. The lower rack houses a number of fixed modules, as well as the system power supply.

The modules are very simple electronic circuits, which function as basic communications building blocks. Each module, fixed or plug-in, has a specific function; functions fall into four general categories:

Signal Generation - oscillators, etc
Signal Processing - multipliers, filters, etc
Signal Measurement - frequency counter
Digital Signal Processing - TMS320C50 based
(DSP & Advanced Modules are not included in the BASIC TIMS-301 SYSTEM)

Modules are patched together via the front panel sockets using interconnecting leads, to model the system under investigation.

SYSTEM CONVENTIONS

All TIMS modules conform to the following mechanical and electrical conventions.

A - FRONT PANEL SOCKETS

Signal interconnections are made via front panel, 4mm sockets

Sockets on the **LEFT HAND SIDE** are for signal **INPUTS**.
All inputs are high impedance, typically 56k ohms.

Sockets on the **RIGHT HAND SIDE** are for signal **OUTPUTS**.
All outputs are low impedance, typically 330 ohms.

YELLOW sockets are only for **ANALOG** signals.
ANALOG signals are held near the TIMS standard reference level of 4V pk-pk.

RED sockets are only for **DIGITAL** signals.
DIGITAL signals are TTL level, 0 to 5 V.

GREEN sockets are all common, or system **GROUND**.

Note that input and output impedances are intentionally mismatched, so that signal connections may be made or broken without changing signal amplitudes at module outputs.

B - PLUG-IN MODULES

Any plug-in module may be placed in any of the 12 positions of the upper rack. All modules use the back plane bus to obtain power supply : only the DSP modules (not part of the BASIC SYSTEM) use the bus to transfer signals. The modules are designed so that they may be plugged-in or removed at any time, without turning off the system power. **The modules are not locked into position and may need to be held while interconnecting leads are removed**.

C - LABELLING

All modules are identified as to the function they perform.
Inputs, outputs, controls and switches are labelled so that a student who has had only a brief introduction to TIMS can use the modules without needlessly referring back to this USER MANUAL.

It should be noted that no variable controls have calibration marks. This is intentional, as the philosophy behind TIMS is that students setup and adjust systems by observing and measuring signals. This assists the student in gaining a much greater understanding, feel and insight into the operation of a communications implementation.

D - BASIC MODULE LIST

Below are listed all the BASIC SYSTEM MODULES. FIXED modules are located in the lower rack, while PLUG-IN modules can be positioned anywhere in the upper rack.

Adder - plug-in
Audio Oscillator - plug-in
Buffer Amplifiers - fixed
Dual Analog Switch - plug-in
Frequency and Event Counter - fixed
Headphone Amplifier and 3kHz LPF - fixed
Master Signals - fixed
Multiplier - plug-in
Phase Shifter - plug-in
Quadrature Phase Splitter - plug-in
Scope Display Selector - fixed
Sequence Generator - plug-in
Trunks Panel - fixed
Tuneable LPF - plug-in
Twin Pulse Generator - plug-in
Utilities Module - plug-in
Variable DC - fixed
Voltage Controlled Oscillator - plug-in
60kHz Lowpass Filter - plug-in

BASIC SPECIFICATIONS

POWER SUPPLY

Input 120, 127, 220 or 240V AC, 47Hz to 63Hz
Output + 15V, 2.2A DC
-15V, 2.2A DC
Protection short circuit, overload, thermal
Regulation 0.2%

PHYSICAL

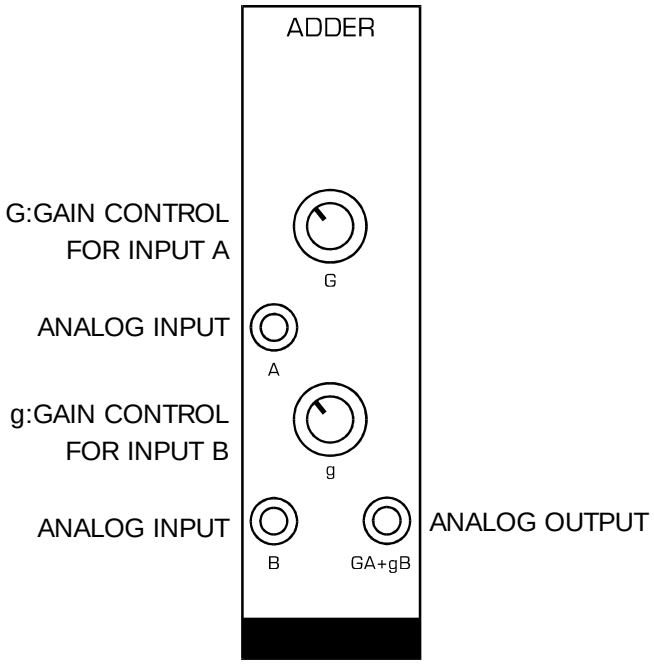
Case Dimensions 490(W) x 330(D) x 310(H) mm
System Weight 10kg
Plug-in Card Dimensions 160 x 100 mm
Plug-in Card Bus Connectors 64 way, 2 row, Eurocard

MODULES

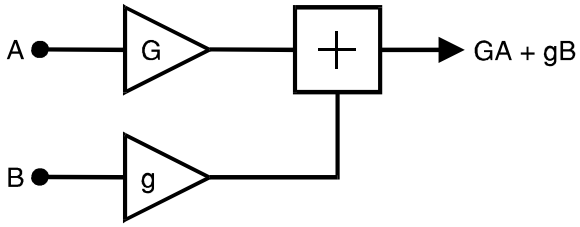
Specifications for each module are listed in the following pages.

ADDER

Two analog input signals **A(t)** and **B(t)** may be added together, in adjustable proportions **G** and **g**. The resulting sum is presented at the output.



FRONT PANEL



BLOCK DIAGRAM

USE

Care must be taken when adjusting the gains to avoid overloading the following modules. Overloading will not cause any damage but it means non-linear operation, which is to be avoided in analog systems. The ADDER is capable of delivering a signal well in excess of the standard reference level, 4V pk-pk, given a standard level input.

The ADDER can also be used as a normal amplifier by using only one input and turning the gain of the other input to minimum. It is not necessary to ground the unused input.

Note that gains **G** and **g** are negative. All inputs and outputs are DC coupled.

BASIC SPECIFICATIONS

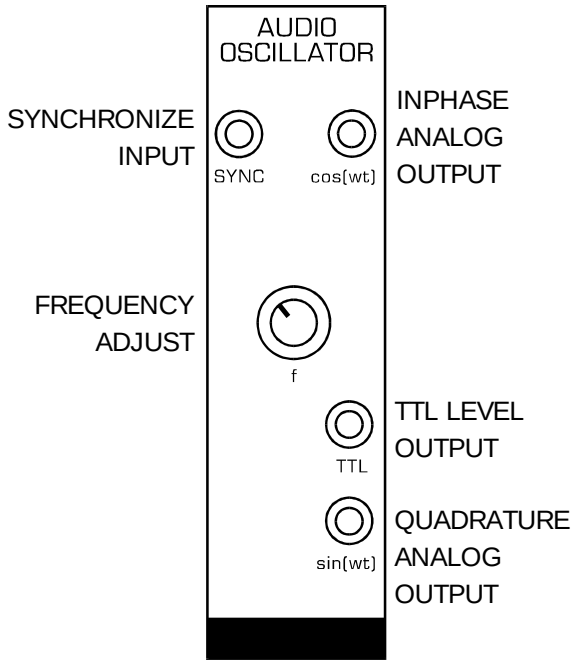
Gain Range $0 < G < 2$;
$0 < g < 2$;
Bandwidth approx 1MHz
Output DC Offset < 10mV, open circuit inputs

PARAMETERS TO NOTE

maximum output level; linearity; polarity inverting; phase shift

AUDIO OSCILLATOR

The AUDIO OSCILLATOR is a low distortion tuneable frequency sinewave source with a frequency range from 500Hz to 10kHz. Three outputs are provided. Two outputs are sinusoidal, with their signals in quadrature. The third output is a digital TTL level signal.



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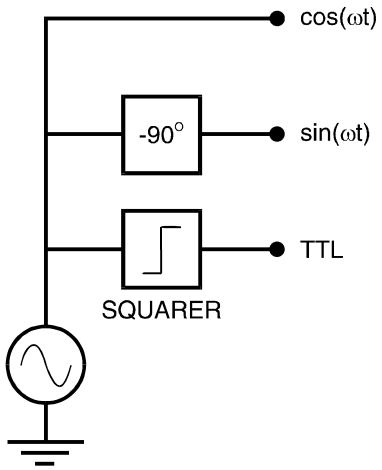

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USE

The frequency of each of the three outputs is the same and is varied by the front panel Δ **f** control. Both the in-phase and quadrature analog output signals have fixed amplitude. Their shape is sinusoidal, having a distortion of less than 0.1%.

The AUDIO OSCILLATOR may be synchronized to an external periodic signal by connecting such a signal to the front panel **SYNC** input. A signal of about 1 volt peak is adequate for this purpose. For synchronization to be achieved, the AUDIO OSCILLATOR must be manually tuned to within a few percent of the frequency to which synchronization is desired.

BASIC SPECIFICATIONS

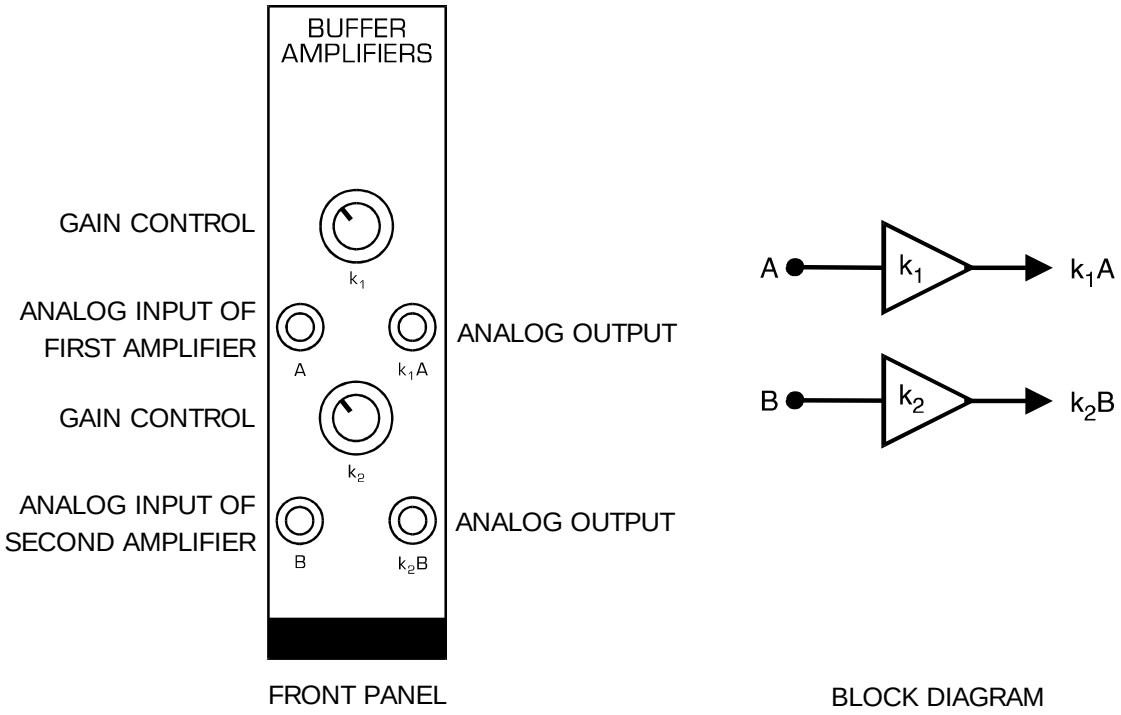
Frequency Range 300Hz to 10kHz
Analog Output Level 4V pk-pk
Distortion < 0.1% analog outputs only
Digital Output TTL level

PARAMETERS TO NOTE

frequency range; relative phase of outputs; amplitude stability with frequency range; harmonic content; short term stability; synchronizing characteristic.

BUFFER AMPLIFIERS

Two independent variable gain amplifiers are provided.



FRONT PANEL

BLOCK DIAGRAM

USE

These buffers may be used to amplify small signals or attenuate large signals. Each amplifier has its own gain control on the front panel.

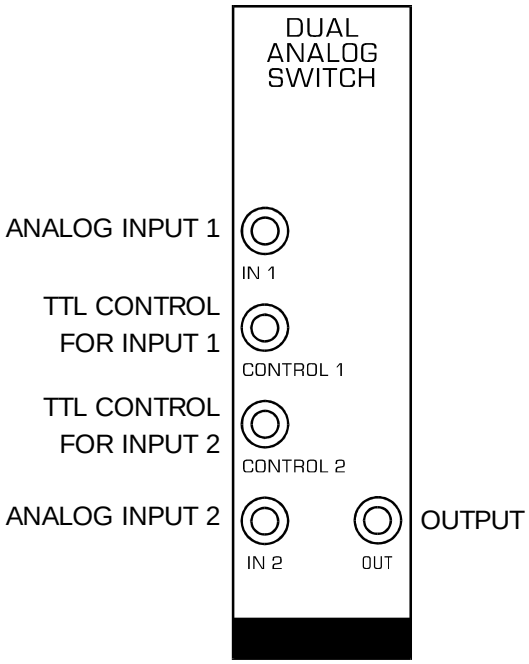
Care should be taken to ensure that later modules are not overloaded due to excessive gain. Overload will not cause any damage but it means non-linear operation, which is to be avoided in analog systems. If overload occurs, turn the gain control counter clockwise.

BASIC SPECIFICATIONS

Bandwidth DC to approx 1MHz
Gain 0 to 10

DUAL ANALOG SWITCH

Two identical analog switches are controlled by digital, TTL level signals. The outputs of the two switches are added internally and presented at the output of the module.



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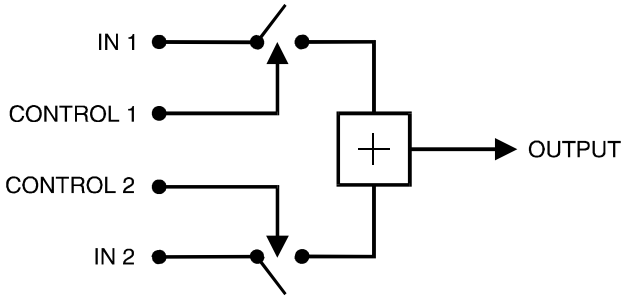

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USE

Each switch may be closed independently by a TTL HIGH at the respective control input. The switch outputs are combined internally and are presented at the common output socket. Open circuit voltage gain between each input and the module output is unity when the switch is closed.

BASIC SPECIFICATIONS

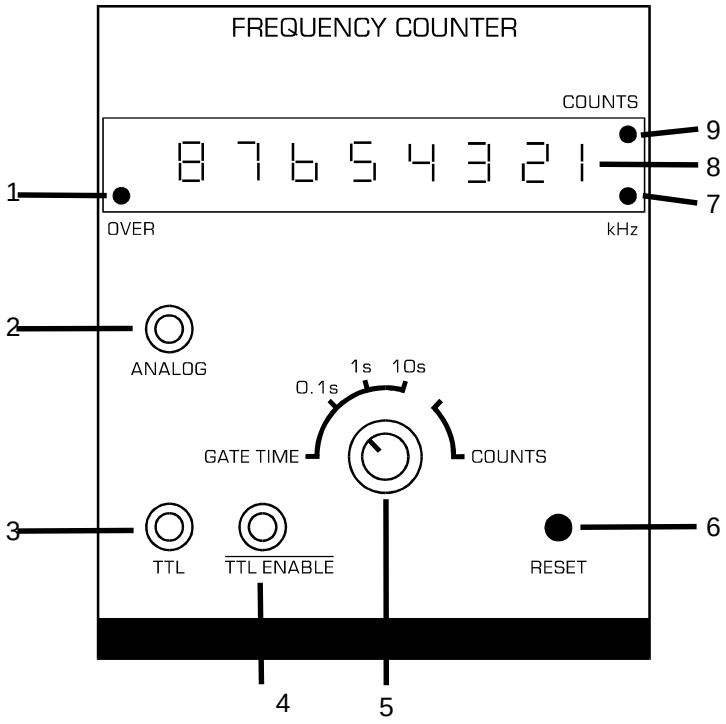
Analog Input Bandwidth > 300kHz
Maximum CONTROL clock > 100kHz
CONTROL Input Levels TTL only
Maximum Analog Input Level ± 8V

PARAMETERS TO NOTE

switch On/Off ratio; linearity; switching speed; analog bandwidth; channel cross talk; DC off-set

FREQUENCY COUNTER

The TIMS counter is an 8 digit, 10MHz frequency and event counter.



BASIC SPECIFICATIONS

1 OVERflow indication LED

2 ANALOG input:

Bandwidth 40Hz to 1 MHz

Sensitivity 250mV typically, @ 100kHz

Maximum input ± 12V

3 TTL Input:

Bandwidth DC to 10MHz

Input TTL level signals only

4 TTL ENABLE may be used to gate the TTL input signal.
Specifications are same as for the TTL input.

5 Mode and Range rotary switch

Frequency counter mode Gate time selection of 0.1s, 1s or 10s with reading in kHz

Event counter mode displays number of pulses counted since the last RESET

6 RESET Push Button resets the count of the Event Counter to zero

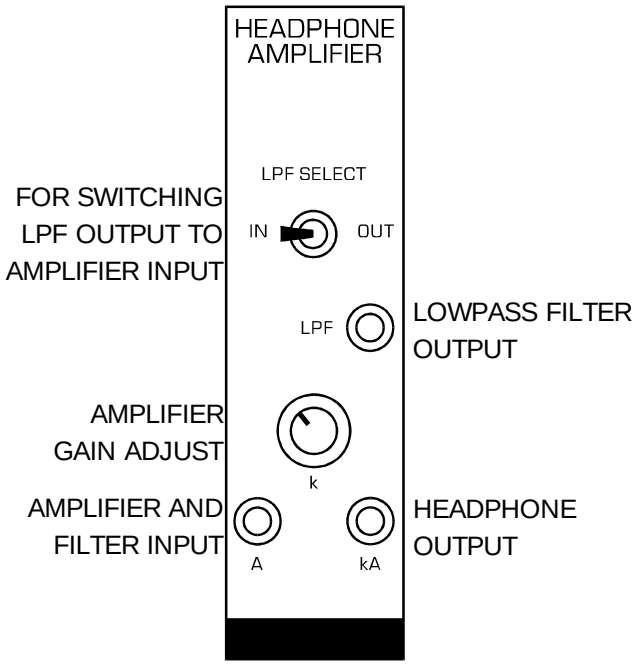
7 kHz LED is lit when counter is in FREQUENCY COUNTER mode

8 8 digit, 7 segment display of frequency or pulse counts;
maximum display 99999999

9 COUNTS LED is lit when counter is in EVENT COUNTER mode

HEADPHONE AMPLIFIER and 3kHz LPF

The HEADPHONE AMPLIFIER is a wideband, variable gain audio amplifier which will drive standard 8ohm headphones or a speaker. An independent 3kHz LOWPASS FILTER may be switched in before the audio amplifier, if required.



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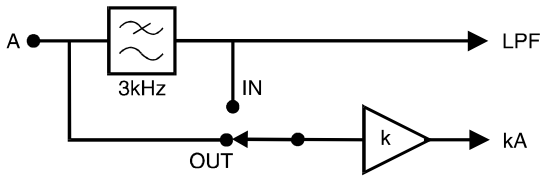


BLOCK DIAGRAM

USE

This module serves as an electro-acoustic interface between the audio signals within the system and the user. Included within the HEADPHONE AMPLIFIER module is an independent LOWPASS FILTER with a 5th order elliptic characteristic. The filter's cutoff frequency is 3kHz, stopband attenuation is 50dB and passband ripple is 0.2dB.

BASIC SPECIFICATIONS

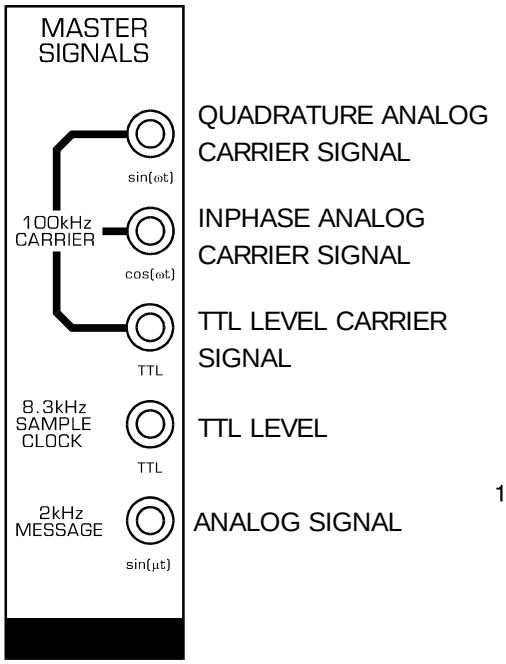
AUDIO AMPLIFIER	**Bandwidth** < 100kHz
	THD 0.2% (R_L= 8ohms, P= 125mW)
	Maximum Gain 20
	Maximum Output Power 500mW
	Output Impedance 8 ohms
LOWPASS FILTER	**Cutoff Frequency** 3kHz
	Stopband Attenuation 50dB
	Passband Gain approx 1
	Passband Ripple 0.2dB

PARAMETERS TO NOTE

filter corner point; filter shape; passband ripple; out-of- band attenuation; amplifier distortion

MASTER SIGNALS

Five synchronized analog and digital signals are available, ranging from 2kHz to 100kHz. The function and frequency of each signal is indicated on the front panel.



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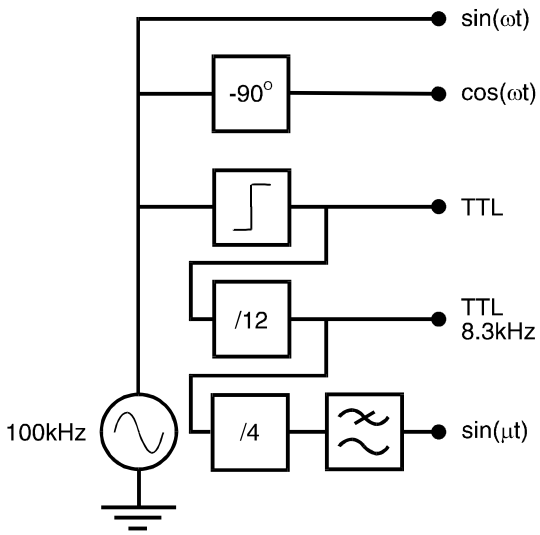


BLOCK DIAGRAM

USE

Signals are labelled as follows:

CARRIER signals are 100kHz, which for modelling purposes is sufficiently far from the audio channel bandwidth of 3kHz.

The **SAMPLE CLOCK** of 8.3kHz, which may be used to sample bandwidth-limited (3kHz) audio message signals.

MESSAGE provides an audio frequency signal which is synchronized to a sub-multiple of the carrier to enable 'text-book' like displays of simple modulation schemes to be achieved.

The five signals are derived from a master crystal oscillator resulting in low frequency drift. Their frequencies are fixed internally. The output levels are also fixed. To vary the amplitude, the signals may be applied to the neighboring buffers.

The analog signals are sinusoidal in shape, having a distortion of less than 0.1%.
Digital signals are all standard TTL level, with rise times of better than 80nsec.

BASIC SPECIFICATIONS

Output Frequencies 100kHz, carrier
8.333kHz, sample clock
2.083kHz, audio (carrier sub-multiple)

Output Levels 4V pk-pk, analog
TTL level, digital

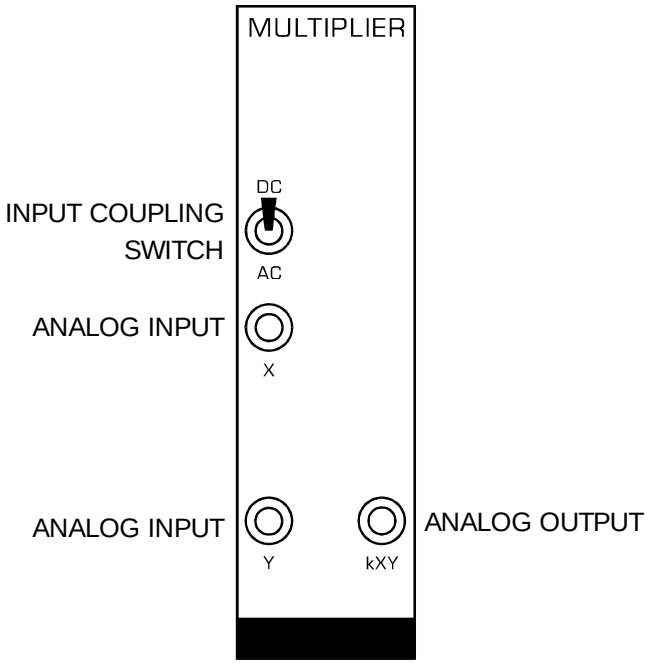
Distortion < 0.1%, analog outputs only

PARAMETERS TO NOTE

short term frequency stability; relative phase of quadrature outputs; harmonic content.

MULTIPLIER

Two analog input signals **X(t)** and **Y(t)** may be multiplied together. The resulting product is scaled by a factor of approximately 1/2 so that, with standard level inputs, later stages are not overloaded.



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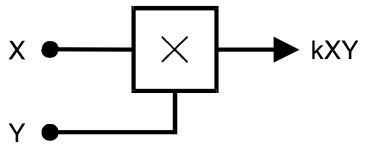


BLOCK DIAGRAM

USE

The input coupling switch may be used to remove input DC components by switching to AC coupling. It should be noted that any DC component in the output will not be removed.

The "k" factor (a scaling parameter associated with "four quadrant" multipliers) is approximately one half. It is defined with respect to the OUTPUT from the module and may be measured experimentally.

BASIC SPECIFICATIONS

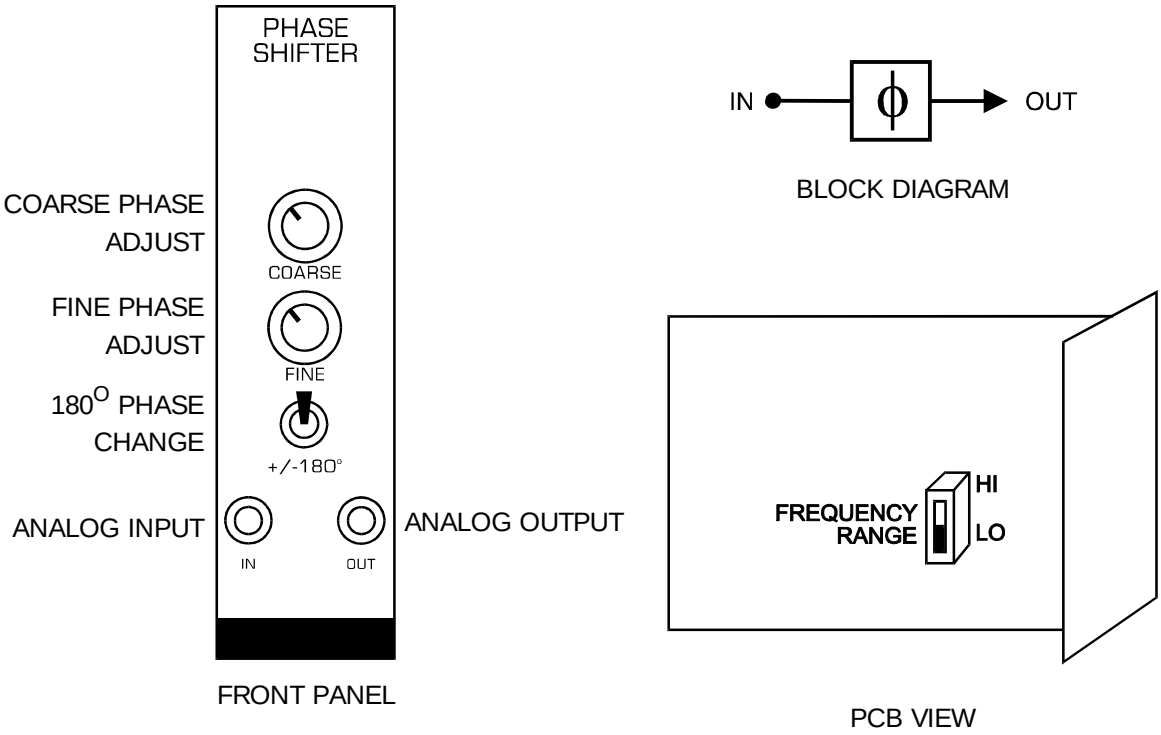
Bandwidth approx 1MHz
Characteristic k.X(t).Y(t)
k approx 1/2

PARAMETERS TO NOTE

linearity; k factor; carrier leak; phase response; DC off-set; performance as a squarer; frequency response; "conversion gain" as a (de)modulator.

PHASE SHIFTER

The PHASE SHIFTER introduces a phase shift between its input and output. This phase shift is adjustable by the user. The frequency range of operation can be selected by PCB mounted switch.



USE

This variable PHASE SHIFTER is capable of varying the magnitude of the phase shift through 360 degrees in two steps. The 180 degree switch selects the step or region of interest; the **COARSE** and **FINE** controls are used to then obtain the required phase shift, Φ.

If the input is COS(μt), then the output is COS(μt- Φ), where Φ lies between 0 and 180 degrees. Although the PHASE SHIFTER will operate from a few hertz up to 1MHz it has been optimized to operate in the neighborhood of two frequencies: around 100kHz in the HI range and around 2kHz in the LO range. A PCB mounted switch is used to select the frequency range.

The open circuit gain through the PHASE SHIFTER is essentially unity for all phases, but note that the amount of phase shift, Φ, is a function of frequency. This is NOT a wideband phase changer: thus all the frequency components of a complex signal's spectra are not shifted by the same phase.

BASIC SPECIFICATIONS

Bandwidth < 1MHz

Frequency Range HI approx 100kHz *
LO approx 2kHz *

* For 0 to 360 degree range of phase shift. The phase shift range increases (i.e. resolution decreases) as the input frequency increases.

Coarse approx 180 degrees shift

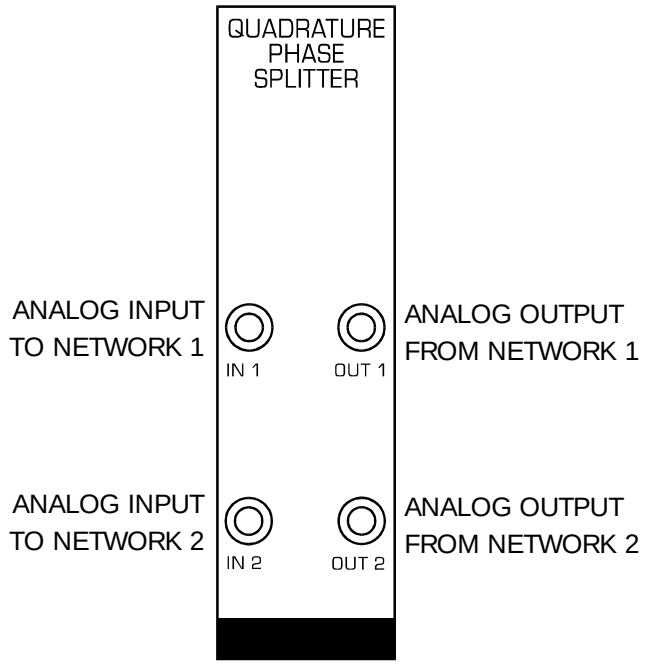
Fine approx 20 degrees shift

PARAMETERS TO NOTE

Variation of phase change with frequency change.

QUADRATURE PHASE SPLITTER

When the same analog signal is applied to both inputs, the two output signals will differ in phase by 90 degrees. The phase splitter networks are wideband, typically covering the range from 200Hz to 10kHz.



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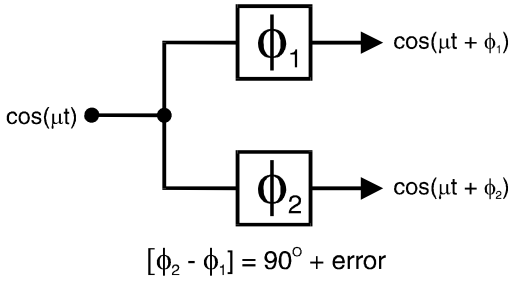


BLOCK DIAGRAM

USE

The QUADRATURE PHASE SPLITTER consists of two wideband phase shifting networks. The networks' phase responses vary with frequency in a complimentary manner, giving a 90 degree phase difference between the outputs, over a wide frequency range.

In communications the most important application is the generation and demodulation of Single Sideband by the "phasing method".

BASIC SPECIFICATIONS

Frequency Range 200Hz to 10kHz typically
Phase Response 90 degrees between outputs, given the same input signal to both networks.

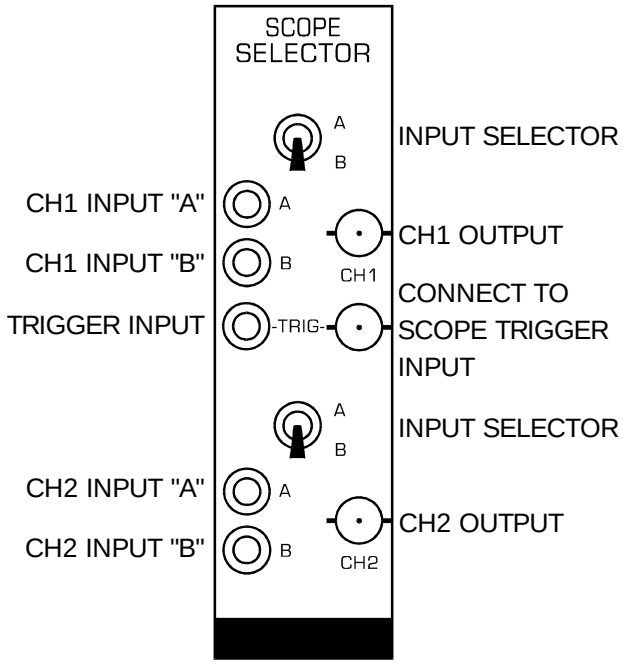
PARAMETERS TO NOTE

Phase error from 90 degrees. This may be measured directly (difficult !) or calculated from side-band suppression measurements.

SCOPE SELECTOR

(OSCILLOSCOPE DISPLAY SELECTOR)

The OSCILLOSCOPE DISPLAY SELECTOR allows 2 of 4 different signals to be viewed simultaneously on a 2 channel oscilloscope. A third input labeled TRIG is ideal for connecting a trigger signal to the oscilloscope's external trigger input.



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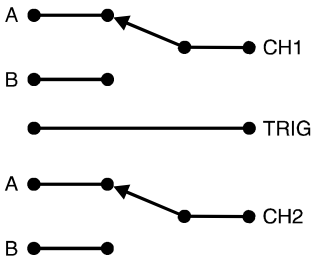


DIAGRAM

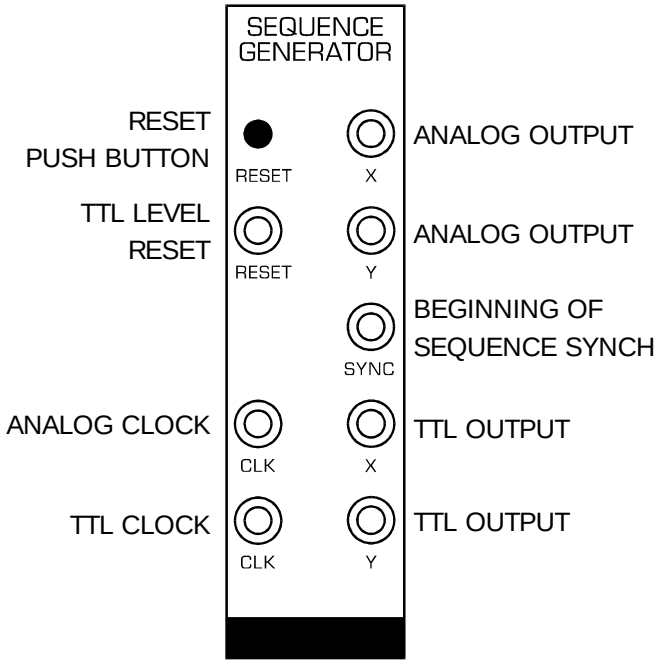
USE

Connection to the oscilloscope is via BNC sockets. Inputs are standard 4mm sockets. Although the input sockets are YELLOW (analog), either analog or digital signals may be examined.

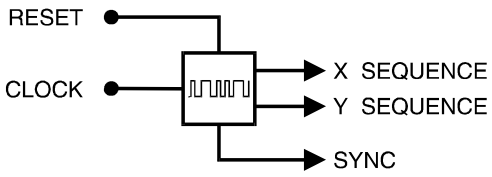
SEQUENCE GENERATOR

(PSEUDORANDOM SEQUENCE GENERATOR)

Using a common external clock signal, the sequence generator outputs two independent pseudorandom sequences **X** and **Y**. A **SYNC** output is provided which is coincident with the start of the sequences. The sequences may be stopped and restarted at any time via front panel controls. Sequences **X** and **Y** are available as either standard TTL or analog level output.



FRONT PANEL



BLOCK DIAGRAM

USE

An external clock signal must be provided to operate the SEQUENCE GENERATOR. This may be sinusoidal or TTL: separate input sockets are used.

The sequences may be stopped at any time by either depressing the **RESET button** or applying a TTL HI signal to the **RESET input**. To restart the sequences from the beginning, release the **RESET button** or apply a TTL LO to the **RESET input.**

The length of the sequences may be selected by a PCB mounted dip switch. Four independent sequence pairs are available from lengths of 2^5 to 2^{11}.

The sequences are selected as follows:

DIP SWITCH CODE		n	SEQUENCE LENGTH 2^n
msb 0	0	5	32
0	1	8	256
1	0	8	256
1	1	11	2048

BASIC SPECIFICATIONS

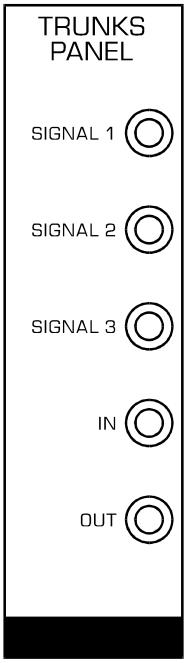
Input Clock Range TTL 1Hz to 1MHz
Analog < 500Hz to > 10kHz
Number of Sequences 4 pairs
Sequence Lengths 2^5, 2^8, 2^8, 2^{11}
Sync indicates start of sequence

PARAMETERS TO NOTE

sequence distribution; noise generation using pseudorandom sequences.

TRUNKS PANEL

The TRUNKS PANEL provides inputs and outputs to signals which are transmitted along the OPTIONAL TIMS BUS classroom network. The three outputs **SIGNAL 1**, **SIGNAL 2** and **SIGNAL 3** present signals from the lecturer's master system. **IN** and **OUT** allow for signals to be respectively received from and transmitted to a neighboring TIMS system.



SIGNALS 1, 2 & 3
COME FROM THE
MASTER TIMS SYSTEM
IF TRUNKS IS CONNECTED

INCOMING SIGNAL FROM ADJACENT STUDENT'S TIMS SYSTEM, IF TRUNKS IS CONNECTED

OUT SENDS A SIGNAL TO THE NEXT STUDENT'S TIMS SYSTEM, IF TRUNKS IS CONNECTED

FRONT PANEL

USE

Note that the TRUNKS PANEL is a module that differs from the TIMS' front panel color code and alignment conventions.

Though the inputs and outputs are YELLOW (analog), either analog or digital signals may be used. Also, the signal input, OUT, which accepts a signal that is to be transmitted to a neighboring TIMS system, is on the right hand side.

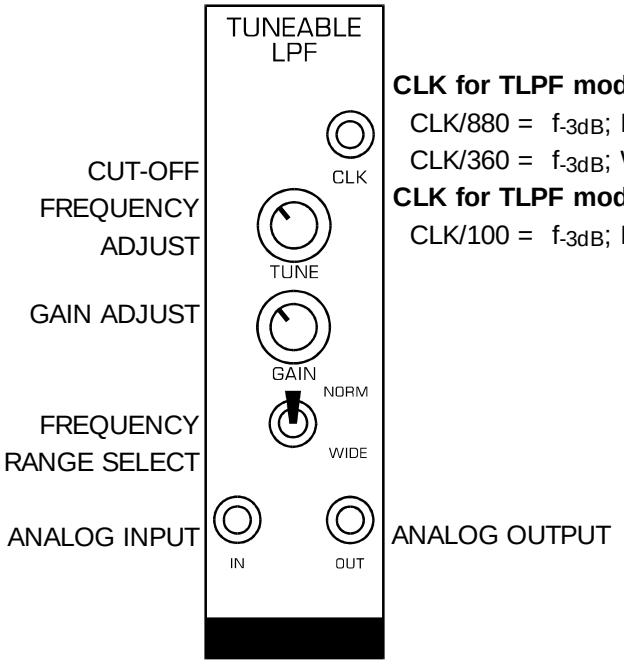
BASIC SPECIFICATIONS when TIMS-TRUNKS is installed

Master Channels 3 : SIGNAL 1, SIGNAL 2 and SIGNAL 3;
Master Channel Bandwidth 700kHz (typ), ac coupled.

Local Channels 2 : IN brings the incoming signal *FROM* an adjacent TIMS' OUT port.
OUT carries the outgoing signal *TO the other* adjacent TIMS' IN port.
Local Channel Bandwidth 350kHz (typ), ac coupled

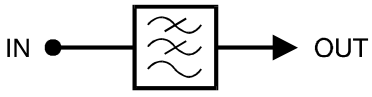
TUNEABLE LPF

The cutoff frequency of this LOWPASS FILTER can be varied using the **TUNE** control. Two frequency ranges, **WIDE** and **NORMAL**, can be selected by a front panel switch. The **GAIN** control allows signal amplitudes to be varied if required.



FRONT PANEL

CLK for TLPF modules V1 to V3:
CLK/880 = f_{-3dB}; NORMAL
CLK/360 = f_{-3dB}; WIDE
CLK for TLPF modules V4:
CLK/100 = f_{-3dB}; NORMAL & WIDE



TUNEABLE

BLOCK DIAGRAM

USE

This lowpass filter has an elliptic filter characteristic. The stopband attenuation is typically 50dB and passband ripple is approximately 0.5dB.

The **GAIN** control is used to vary the amplitude of the output signal. Care should be taken to avoid overloading/saturation. Two frequency ranges are provided. **NORM**AL range provides more precise control over the lower audio band, used for telecommunications message channels. The **WIDE** range expands the filter's range to above 10kHz. The **CLK** output provides an indication of the filter's cutoff frequency.

BASIC SPECIFICATIONS for TLPF modules V1 to V3

Filter Ranges 900 Hz < NORMAL < 5 kHz and
2.0 kHz < WIDE < 12 kHz, continuously variable over each range.
Filter Order 7th order, Elliptic
Stopband Attenuation > 50dB and **Passband Ripple** < 0.5dB

BASIC SPECIFICATIONS for TLPF modules V4

Filter Ranges 200 Hz < NORMAL < 5 kHz and
200 Hz < WIDE < 12 kHz, continuously variable over each range.
Filter Order 5th order, Elliptic
Stopband Attenuation > 50dB and **Passband Ripple** < 0.5dB
Maximum Input Voltage + 5V to -5V (TTL-level input signal is acceptable)

PARAMETERS TO NOTE

corner point; phase shift; gain range; passband ripple; out of band attenuation.

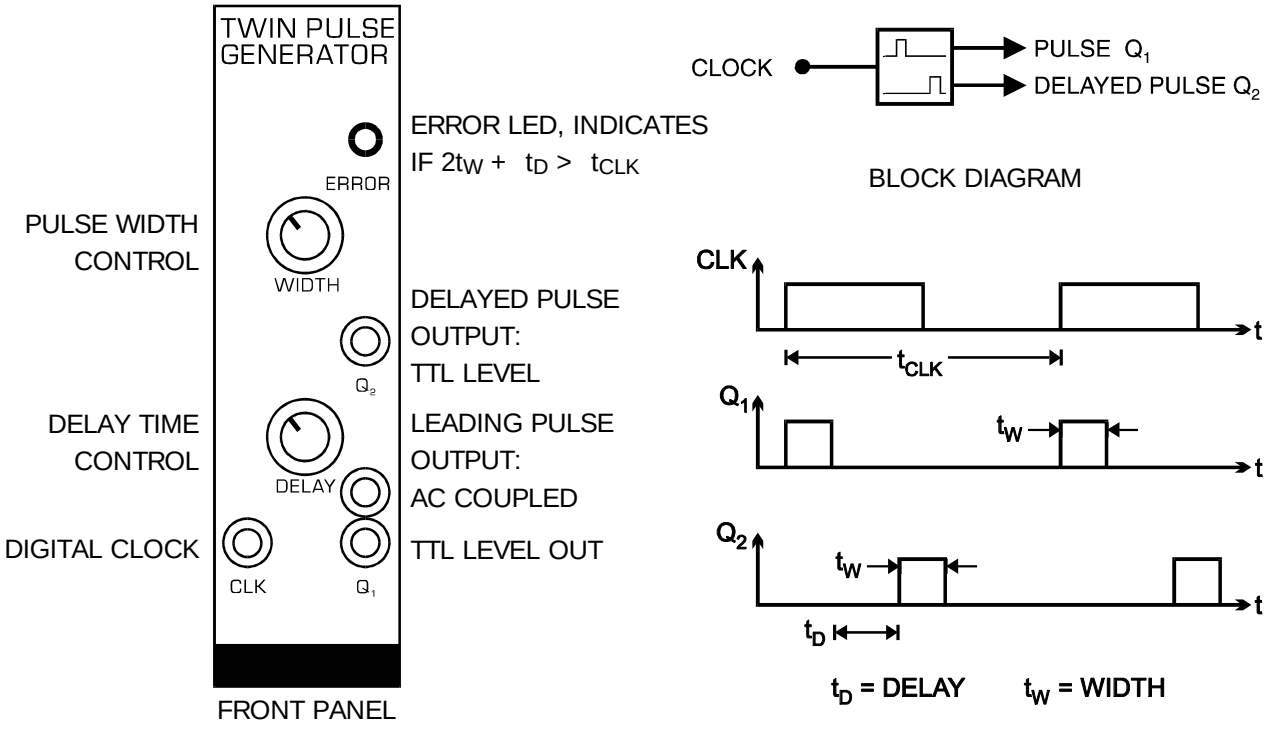
TWIN PULSE GENERATOR

(TWIN PULSE GENERATOR - VERSION 2.0)

A positive going edge applied at the **CLOCK** input causes a positive pulse to occur at the output terminals. There are two operating modes: TWIN and SINGLE. Only TWIN mode is limited to low frequency **CLOCK** inputs.

In TWIN mode, **Q_1** outputs the leading pulse and **Q_2** outputs the delayed pulse. The time between pulses **Q_1** and **Q_2** can be varied, as can the pulses' widths.

In SINGLE mode, only **Q_1** outputs a positive going pulse, while **Q_2** outputs the inverse of **Q_1.** The pulse width can be varied.



USE

A digital TTL level signal is applied to the **CLK** input. The GENERATOR then outputs one or two pulses, depending upon the operating mode selected. Use the PCB mounted MODE switch to select either SINGLE or TWIN operating mode.

TWIN MODE

TWIN mode is used when two sequential pulses are needed. Two equal width positive pulses occur as a result of each **CLK** signal positive edge. Pulse **Q_1** always occurs before pulse **Q_2**. The width of both pulses is controlled by the front panel **WIDTH** control. The **DELAY** control varies the spacing between the two pulses. Note that TWIN mode will only accept CLOCK input signals of up to 50kHz, depending upon front panel settings.

If **WIDTH** and **DELAY** have been incorrectly set, causing anomalous operation, the **ERROR LED** will be lit. To eliminate the error reduce **DELAY** and then **WIDTH** - by turning counter clockwise.

SINGLE MODE
SINGLE mode is used to obtain a train of equal width pulses from any TTL level signal.

Equal width positive pulses occur at **Q_1** output as a result of each **CLK** signal positive edge. The width of the pulses is controlled by the front panel **WIDTH** control. **Q_2** simultaneously outputs the compliment of **Q_1**. The **DELAY** control is not used in this mode.

Note that **Q_1** includes both a TTL level and an AC coupled output pulse.

BASIC SPECIFICATIONS

TWIN MODE
Clock Frequency Range < 50kHz
Pulse WIDTH 3µs < t_w < 25µs
Pulse DELAY Q2-Q1 10µs < t_d < 120µs
Error Indication $2t_w + t_d > t_{CLK}$

SINGLE MODE
Clock Frequency Range < 200kHz
Pulse WIDTH 3µs < t_w < 25µs

UTILITIES MODULE

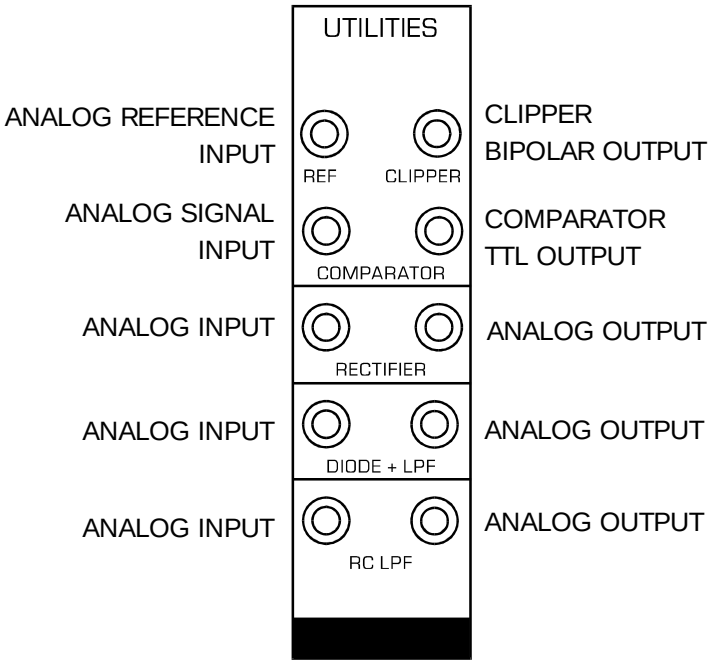
The Utilities Module houses 4 independent functional blocks:

(i) A signal COMPARATOR with TTL output and CLIPPER with bipolar output, for squaring analog waveforms. The COMPARATOR's threshold level may be set as required by applying a DC voltage to the REF input. The CLIPPER's gain may be set by adjusting DIP switches **SW1** and **SW2**.

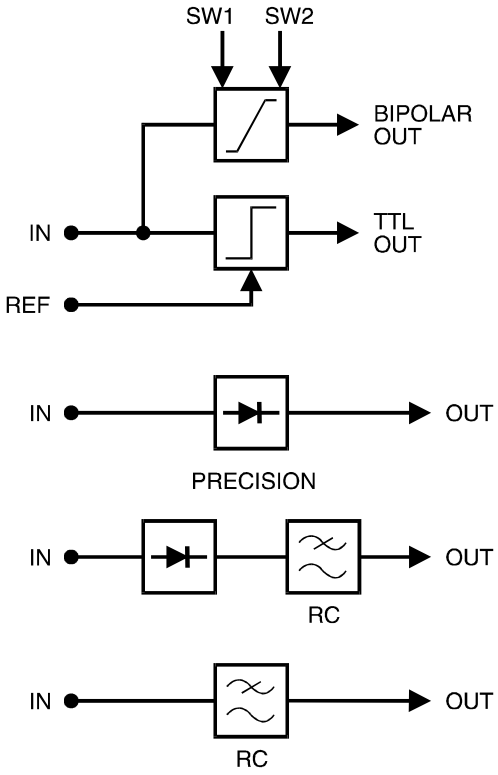
(ii) Precision halfwave RECTIFIER.

(iii) Simple diode and single pole, audio range, RC Lowpass Filter.

(iv) Single pole, audio range, RC Lowpass Filter.



FRONT PANEL



BLOCK DIAGRAM

USE

COMPARATOR

The COMPARATOR will square any analog signal and provide a standard TTL level output. The switching threshold level is determined by the voltage level applied to the **REF** input.

NOTE: *For correct COMPARATOR operation, the **REF** input must never be left unconnected.*

The **REF** input may be connected to GROUND, VARIABLE DC or any other signal source.

CLIPPER

The CLIPPER will amplify any analog TIMS level signal and then clip the amplitude of the amplified signal, to a fixed level of approximately $\pm$ 1.8V. The clipping action is performed by standard small signal diodes.

NOTE: *The **REF** input is NOT used by the CLIPPER.*

Adjusting the gain of the CLIPPER, determines whether the clipping action is "*SOFT*", "*MEDIUM*" or "*HARD*". The following table, UTIL-1, relates DIP switch settings to CLIPPER gains and clipping action,

CLIPPING ACTION	**GAIN** (approx)	**DIP SWITCH SETTINGS**	
		SW1 (both a & b)	**SW2** (both a & b)
SOFT	x0.8	ON - ON	OFF - OFF
MEDIUM	x8	OFF - OFF	OFF - OFF
HARD	x40	OFF - OFF	ON - ON
-	not applicable	ON - ON	ON - ON

Table UTIL-1: CLIPPER gain settings

DIP switches SW1 and SW2 will be found in the middle of the UTILITIES module's circuit board.
NOTE: *Both halves (bits) of each switch must be in the SAME position at all times.*

BASIC SPECIFICATIONS

COMPARATOR
Operating Range > 500kHz
TTL Output Risetime 100nsec (typ)

CLIPPER
Operating Range > 500kHz
Output Level 1.8Vpk (typ)
Adjustable Gains 3 steps; x0.8, x8 and x40 (approx)

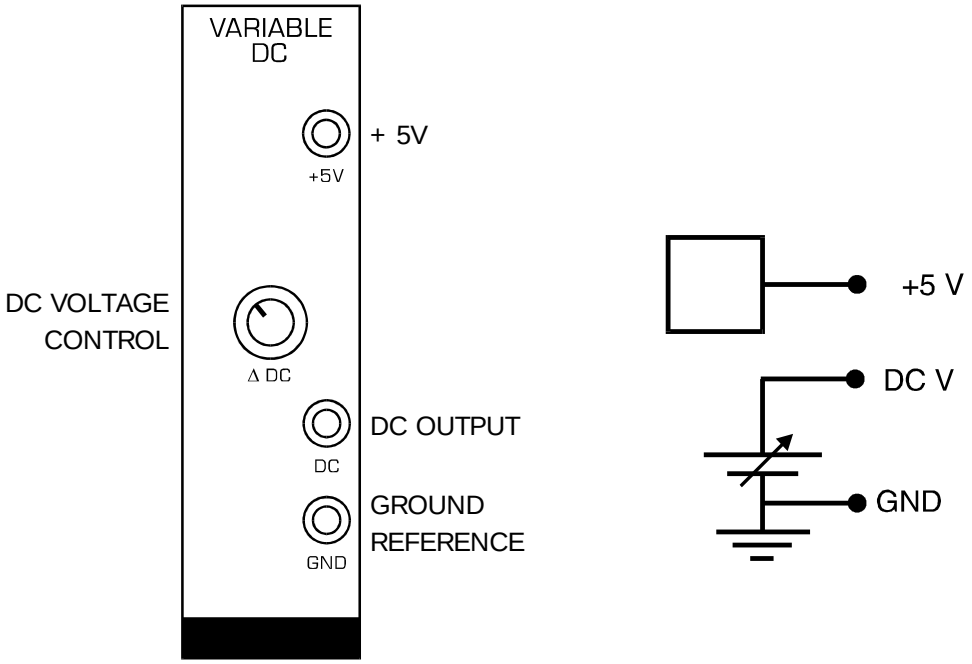
RECTIFIER
Bandwidth DC to 500kHz (approx)

DIODE & LPF
LPF -3dB 2.8kHz (approx)

RC LPF
LPF -3dB 2.8kHz (approx)

VARIABLE DC

The VARIABLE DC module is a stable, bipolar DC source.



FRONT PANEL BLOCK DIAGRAM

USE

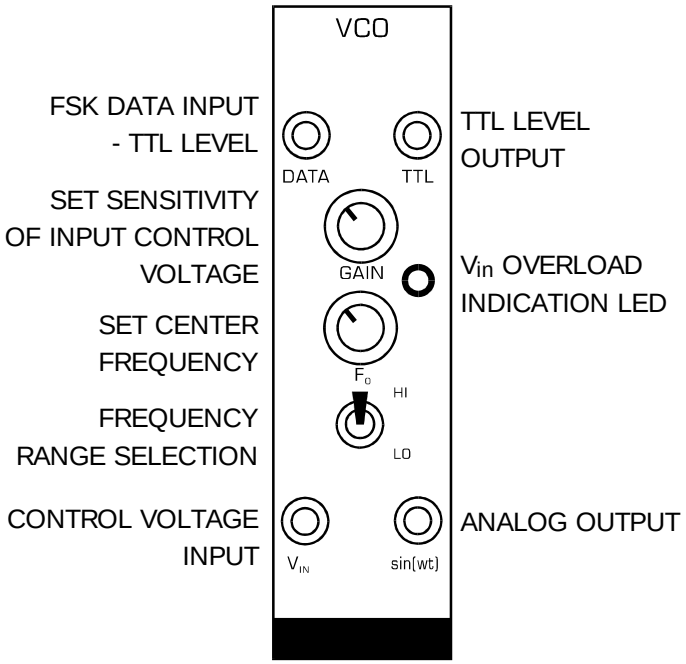
The DC voltage output varies from about -2.5V when the control is fully counter clockwise through zero to + 2.5V when control is turned fully clockwise. If greater resolution or wider range is required, then one of the BUFFER AMPLIFIERS can be used in conjunction with the VARIABLE DC module.

BASIC SPECIFICATIONS

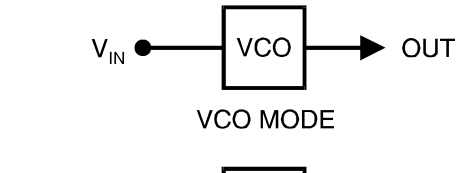
Voltage Range ± 2.5V DC
Short-term Stability < 2mV/hr
Resolution approx 20mV
Output Current < 5mA

VCO

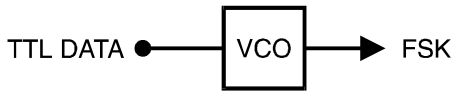
The Voltage Controlled Oscillator module functions in two modes: either as a VOLTAGE CONTROLLED OSCILLATOR with analog input voltage or as an FSK GENERATOR with digital input. Both modes have two frequency ranges of operation which are selected by a range switch. The VCO frequency and input sensitivity can be controlled from the front panel.



FRONT PANEL

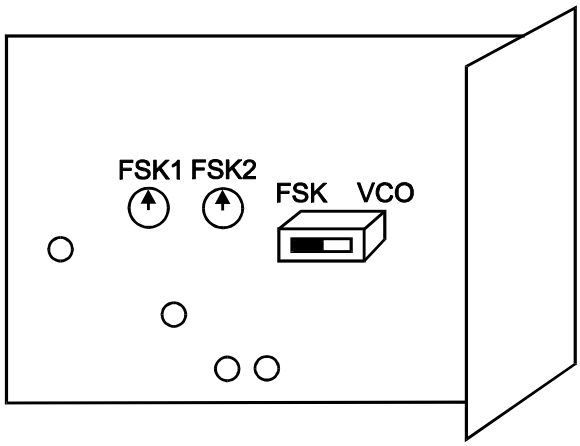


VCO MODE



FSK MODE

BLOCK DIAGRAM



PCB VIEW

VCO USE

STANDARD VCO OPERATION

The VCO output frequency is controlled by an analog input voltage. The input voltage, **V_{in}**, is scaled - amplified - by the front panel **GAIN** control. A DC voltage can be added to **V_{in}** internally, thus setting the start or CENTER FREQUENCY, **f_o** . The CENTER FREQUENCY is defined as the VCO output frequency, when no voltage is applied to the **V_{in}** connector. The **V_{in}** input is internally tied to ground if no signal is applied.

The **V_{in} OVERLOAD LED** is lit when the sum of these voltages - scaled **V_{in}** plus CENTER FREQUENCY DC offset - exceed the oscillator's internal operating limits. Decrease the **GAIN** - turn counter clockwise - and/or shift the CENTER FREQUENCY, **f_o** , to extinguish the LED.

The frequency range switch selects between the **HI** or carrier band and the **LO** or audio band. Both sinewave and digital outputs are available.

SPECIAL VCO OPERATION - FINE FREQUENCY CONTROL

In some applications, fine control may be required over the output frequency of the VCO. This may be easily achieved by following these four steps:

MODULES REQUIRED: VCO and VARIABLE DC.

STEP 1 - Set the VARIABLE DC module's output close to zero (marker knob at 12 o'clock position).

STEP 2.1 - Turn the **GAIN** control of the VCO to zero, fully counter-clockwise.
STEP 2.2 - Now, turn the **GAIN** control up, clockwise, just a little (only a few degrees).

STEP 3 - Set the VCO module's output frequency as close as possible to the frequency of interest. Use the frequency adjust knob, $\mathbf{f_o}$. Use the FREQUENCY COUNTER to measure the VCO's output frequency.

STEP 4 - Finally, patch the VARIABLE DC module's output to the VCO module's frequency control input, $\mathbf{V_{in}}$, with a standard patching lead.

FINE FREQUENCY CONTROL of the VCO module is now achieved by turning the VARIABLE DC module's voltage control knob.

FSK USE

A PCB mounted slide switch selects between FSK and VCO modes of operation. The two output frequencies, $\mathbf{FSK_1}$ and $\mathbf{FSK_2}$, (MARK and SPACE), are set by varying the PCB mounted, finger adjustable trimmers. As in VCO mode, the frequency range switch selects between the **HI** or carrier band and the **LO** or audio band. The digital data input accepts only TTL level signals. Both sinewave and digital outputs are available.

GAIN and CENTER FREQ, $\mathbf{f_o}$, controls and the $\mathbf{V_{in}}$ connector are not used in the FSK mode.

BASIC SPECIFICATIONS

VCO MODE

Frequency Ranges 1.5kHz < LO < 17kHz; sinewave and TTL
(< 300Hz with external input voltage, Vin)
70kHz < HI < 130kHz; sinewave and TTL

Input Voltage -3V < V_{in} < 3V

Overload limit indication LED V_{vco} > $\pm$ 3V;
V_{vco} is the internal voltage finally applied to the VCO circuitry.

GAIN $G.V_{in}$: 1 < G < 2

Center Frequency Voltage Range - 3V < V_{fc} < 3V;
V_{fc} is a DC voltage added INTERNALLY to $G.V_{in}$

FSK MODE

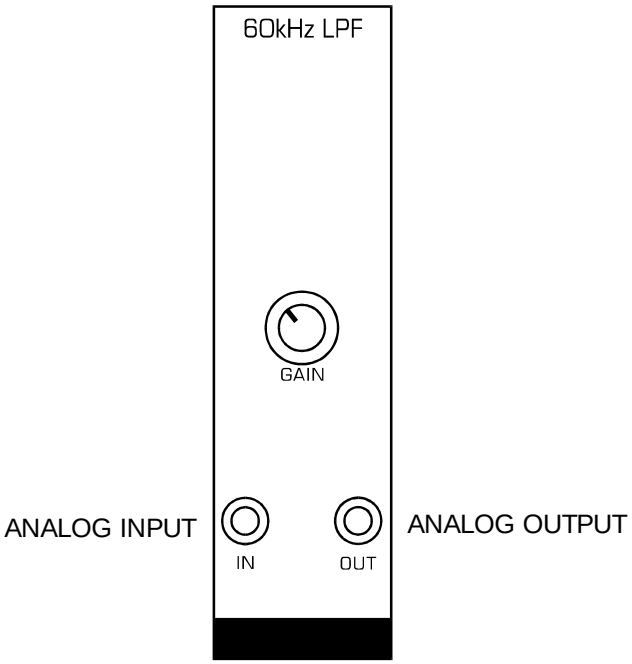
Frequency Ranges 1.5kHz < $FSK_{1,\ LO}$ < 9kHz
500Hz < $FSK_{2,\ LO}$ < 4kHz

80kHz < $FSK_{1,\ HI}$ < 200kHz
20kHz < $FSK_{2,\ HI}$ < 120kHz

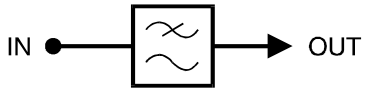
Data Input TTL level message

60kHz LOWPASS FILTER

An elliptic lowpass filter is provided with a cutoff point of approximately 60kHz. The input signal amplitude can be adjusted with the gain control.



FRONT PANEL



BLOCK DIAGRAM

USE

The 60kHz LPF allows carrier signals to be removed from a given signal spectrum.
For example, as the lowpass filter for envelope detector applications.

The **GAIN** control allows input signals to be attenuated, to avoid overloading the filter.

BASIC SPECIFICATIONS

Cutoff Frequency approx 60kHz
Passband Gain variable, 0 to 5 (approx)
Stopband Attenuation 50dB (typ)
Passband Ripple 0.1dB (typ)

PARAMETERS TO NOTE

corner point; response shape; passband ripple; phase shift; out of band attenuation.